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Title of the invention

Light-emitting displays with variable switching voltages and brightness control

Field of application of the invention

Light-emitting displays based on semiconductor materials, particularly GaP, GaAsP and GaAlAs, may be operated without integrated control circuits only at certain currents and voltages.

Light-emitting displays for variable voltages in devices and systems offer a greater number of display and signalling possibilities. By expanding the voltage range up to 50 V for the same operating current, the field of use of the light-emitting displays is considerably increased. Thus, the light-emitting displays may be used without additional wiring and with a low additional power requirement in the automotive industry, in mechanical engineering, in communication engineering, in the appliance industry, in the mining industry, in the construction industry and in metrology.

Characteristics of the known technical solutions

Red light-emitting displays with a series resistor are known. The integrated ohmic resistor means that there is no need for further external wiring up to a maximum operating voltage of 7.5 V. The breakdown voltage is a minimum of 3 V. The LED 5082 - 4860/4468 (hp brochure: RTG E Springorum GmbH 2000 Hamburg 70) with series resistor has the disadvantage that at an operating voltage of 7.5 V more than 5 V falls off over the integrated resistor, which leads to an increased power requirement and to a heating of the diodes. The reliability of the component is thereby decreased.

Moreover, light-emitting arrangements with series resistor and protective diode in a miniature housing are known (HLMP - 6600/6620 hp brochure RTG). The protective diode which is additionally connected in series expands the maximum cut-off voltage range from the typical value of 7.5 V to a maximum of 15 V for the light-emitting diodes. The ohmic resistor that is present is said to guarantee an operationally reliable current flow up to a maximum operating voltage of 6 V.

Furthermore, light-emitting arrangements with an integrated voltage comparator are known (hp 5682 - 4732). The integrated circuit contains a voltage comparator which compares the externally applied voltage with an internally generated threshold voltage and switches the light-emitting diode when the threshold voltage is exceeded. By virtue of a series connection of external components such as Zener diodes, for example, the switching voltage can be varied.

One disadvantage of this arrangement according to the comparator principle is that only a comparison voltage can be predefined internally. It is not possible to vary the threshold voltage. Apart from these arrangements, components are known which in conjunction with integrated circuit arrangements implement flashing functions. In this case, the switching voltage remains constant (brochure material; litronix: Flashing Light Emitting Diode, Red-Lit 4403, Omni Res GmbH 8000 Munich 19).

Object of the invention

The object of the invention is to expand the applicable operating voltage of light-emitting displays without additional external wiring. This means that the components are to operate without external wiring up to maximum operating voltages of, for example, 50 V. The increase in the operating voltage of, for example, 50 V

is to be realized by an integrated circuit arrangement. The connection pins and structural form of the light-emitting arrangement are to as far as possible remain unchanged. The power requirement should be low and the reliability of the components should be high.

Summary of the invention

It is an object of the invention to expand the field of use of light-emitting displays without external wiring from 2 V to 50 V in a variable manner. According to the invention, the object is achieved in that an integrated circuit arrangement is realized in an integrated manner and is connected to the light-emitting components. The control circuit is mounted on the same support strip as the light-emitting component. In this case, solder islands are provided on the integrated circuit for the purpose of contacting with the light-emitting displays and/or the external connections.

Furthermore, the circuit chip is arranged under the light-emitting diode chip. The light-emitting displays are in this case adhesively bonded to the circuit chip and electrically connected to the circuit by means of thermocompression or conventional soldering methods. The circuit arrangement is designed as a constant current source. The constant current source is in the simplest case formed by two transistors, one high-ohmic resistor and one low-ohmic resistor. The constant current of the light-emitting display is determined by the magnitude of the low-ohmic resistor. This is effected by a parallel connection of resistors being provided in the layout and the desired current being provided by different contacting in the conductor track plane.

Furthermore, parallel connection paths are burnt out by applying a defined rush of current, and hence a constant current is set depending on the application.

A further possibility for line balancing of the light-emitting displays lies in integrating a voltage-dependent multivibrator in the constant current generator. When the voltage is increased, the pulse duty factor or the frequency of the multivibrator is increased and hence less power is transferred via the load resistor.

These integrated controls are used both in individual diodes and for diode arrangements such as rows, numerical and alphanumerical multiple arrangements. When using multicolour chips, that is to say when part of the chip emits red and green light for example, the colours can be switched on in steps or mixed light can be switched in a voltage-dependent manner from red- and green-emitting diodes, as a function of the doping, the material used and the applied voltage. When using two- and three-chip variants to produce multicolour light-emitting diodes, it is advantageous to integrate a control circuit in front of, below or next to each diode chip or row.

Apart from the functions of keeping the current constant and reducing the power consumption by increasing the pulse duty factor as a function of the applied voltage, the control circuit also carries out brightness control. The brightness control takes place according to the invention dynamically and statically. In the case of static brightness control, the level of the constant current is defined by burning out a conductor track on the control chip by means of a one-off application of a predefined voltage from outside. In the case of dynamic brightness control, a photoreceiver is integrated which controls the pulse duty factor of the voltage-dependent multivibrator as a function of the incident light and thus determines the brightness of the light-emitting display. According to the invention, the photoreceivers are integrated in or on the substrate material of the control circuit and contacted and/or are applied as an

individual chip. When incorporating such circuits in display units which have the structural form of a light well, the brightness control is limited by the fact that light shines into the component from the sides. In order to reduce or prevent the entry of light from outside into the component and to prevent the exit of the emitted light of the diode chip to the outside, according to the invention the diode chips are placed on mesa-etched bumps or are placed in for example stamped cavities which bring about a reflective effect. The mesa bumps and/or the reflective cavities are made from printed circuit boards, for example cenausite, ceramic or film supports.

Example of embodiment

The invention will be described below with reference to examples of embodiments.

Fig. 1 shows the circuit diagram for the integrated constant current source. The constant current source is formed by two transistors 1 and 2, and the constant current through the light-emitting diode 5 is defined by means of one high-ohmic resistor 3 and one low-ohmic resistor 4. The operating voltage is applied to the contacts 6 and 7. The mounting of the constant current source is shown in Fig. 2. The constant current source 9, formed in an integrated manner, is mounted in the reflector 10 next to the diode chip 8. The integrated circuit is connected to the diode chip 8 and the terminal contacts 12 by the connection wires 11.

In light well displays, the light from a light source mounted approximately in the centre of the light well is guided by the highly reflective walls of the light well such that at the upper end of the light well an essentially homogeneous brightness is achieved.

Fig. 3 shows the principle of such an arrangement. The conductor tracks 14a and 14b needed to supply current to the light source are applied to an electrically insulating material 13. These conductor tracks may also be potted by an insulating material. The light source 17 is fixed for example by an electrically conductive substance 18 and receives the second electrical connection via a conducting wire 16. A light distribution that is as homogeneous as possible is achieved at the upper exit opening of the light well by virtue of the configuration of the highly reflective light well walls 15. Fig. 3 shows the "sealing" of the light source support in an idealized manner, that is to say that no light can pass into any neighbouring light wells that may possibly be present ("light crosstalk") or leave the display at the sides. Most 20 of the emitted light leaves the light well at the upper exit opening; only a small part 19 is lost through the insulation gap 23 between the two conductor tracks 14a and 14b. The surfaces of the latter are likewise highly reflective. In this way it would be possible to use about 80% of the light emitted from the light source 17.

On account of manufacturing tolerances, it is in practice not possible to achieve the ideal situation (Fig. 3). Fig. 4 shows the realistic case. A gap 22 is left between the light well walls 15 and the light source body, through which gap up to 30% of the light 21 emitted by the light source can be lost. The aim is to largely avoid these losses in that, by changing the light source mounting location with respect to the reflector body or by virtue of additional reflective barriers, the shape of which has to be matched to the shape of the light well walls, the exit of light 21 is almost completely avoided and the small part of emitted light 19 is partially prevented and used to increase the brightness at the upper opening of the light well. This concept will be illustrated in the following examples of embodiment.

By raising the mounting location of the light source with respect to its surroundings (Fig. 5), the light source is inserted further into the light well body and as a result the direct exit of light through the gaps 22 and 23 is significantly reduced.

In this variant, it may be necessary for technological reasons likewise to raise the conductor track 14b of the conducting wire 16. Fig. 6 shows a variant in which the exit of light through the gap 22 is prevented by a reflective barrier on the conductor tracks 14a and 14b. In order to retain as good a homogeneity as possible of the brightness at the upper light well opening, the shape of the reflective barrier must be matched to the shape of the light well and the emission characteristic of the light source.

In the variants of Fig. 7 and Fig. 8, a reflector which surrounds the light source deflects the light emitted by the light source such that the light cannot leave the light well directly though the gaps 22 and 23. In this case, too, the reflector 14 made from the conductor track 14a must be matched in terms of its shape to the shape of the light well and the emission characteristic of the light source.